

Optimal dosimeter deployment in an urban area for wideband RF-EMF exposure assessment

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Summary

A novel methodology is presented to extend an existing sensor network in Santander, Spain, with low-complexity dosimeters able to continuously measure the electric-field strength in multiple radiofrequency bands. The procedure consists in using both simulation and measurement data to achieve an optimal deployment design, i.e., a dosimeter deployment that will provide relevant exposure statistics and will allow the creation of exposure maps. We present here the deployment procedure, while the complete design optimization will be validated later in Year 2015.

Introduction

One of the main outcomes of the European “Low EMF Exposure Future Networks” (LEXNET) project, which aims at designing a set of techniques and procedures to reduce the exposure of a population to radiofrequency (RF) electromagnetic fields (EMF) in an area without jeopardizing their quality of experience, is the definition of a new metric, coined *Exposure Index* (EI) and conceived to assess the global exposure of the population, considering both personal devices and network access elements (e.g., mobile-phone base stations and Wi-Fi access points) [1]. Hence, the evaluation of the EI requires the assessment of both far-field and near-field RF-EMF exposure over large scenarios and extended periods of time. It is within this framework that the study presented here focuses on the characterization of the far-field exposure of a population at different radiofrequencies corresponding to the main wireless communication technologies.

While in the past, far-field exposure has been measured by means of sophisticated devices, the need for a large-scale assessment resulted in the choice of a grid of fixed low-complexity dosimeters [2]. Here, we will describe the methodology that is being followed in LEXNET to ensure an optimal deployment grid that, in turns, will provide relevant exposure statistics and will allow the creation of exposure maps in the selected area.

Description of the methodology

The goal of this study is an accurate characterization of the far-field RF-EMF exposure in a given area using a fixed grid of low-complexity dosimeters, and consists in obtaining both a good approximation of the statistical distribution of the electric-field strength, as well as developing an interpolation model of the electric-field strength with reasonable accuracy.

To achieve both with a minimal amount of resources, the methodology here proposed is based on a combination of radio-planning-like simulation techniques (SIRADEL, Saint-Grégoire, France), which consider the target scenario characteristics, and a measurement-based iterative deployment procedure [5,6], which addresses the optimization of the sensor deployment.

The complete sequence of steps is foreseen as follows (Figure 1):

- (1) Before the deployment process, an initial radio-planning-like simulation, based on accurate area information [4], is performed to study the RF exposure in the target area due to the present base stations transmitting at various frequencies (e.g., 900, 1800, and/or 2100 MHz). This simulation will provide a statistical estimation of the required dosimeter density.
- (2) In the initial deployment phase, there will not be any real measurement data to guide the dosimeter positioning, and a preliminary simulation study will be used to offer an initial partial deployment.
- (3) After a certain period of time, the dosimeter measurements are analyzed, and, if not all dosimeters have been deployed, our sequential algorithm will estimate optimal locations for the next phase of deployment [5,6]. This step is repeated until all dosimeters are distributed.
- (4) Once the whole deployment is completed, the obtained measurements will be used to calibrate simulation tools and models.

Pilot study

In order to validate our proposed methodology, a dosimeter network will be deployed in downtown Santander, Spain, covering a surface of 0.35 km² (highlighted in Figure 2), with a large number of mobile-phone base stations either within the target area or nearby (Figure 2). In particular, the dosimeters will be integrated within an Internet of Things (IoT) platform, the SmartSantander testbed [3], which is the main outcome of a former EU project on Smart-Cities. The low-complexity dosimeters will act as regular IoT nodes to facilitate the process of gathering the produced data offered by the testbed.

A simulation-based study of the deployment area has shown that 25 dosimeters will be able to provide an appropriate accuracy for the area of interest. The actual installation and deployment will soon be started.

Conclusions

The final outcome of this study will allow the assessment of the RF-EMF exposure induced by cellular networks in real-time in a medium-sized city. In a nutshell, based on initial simulation results over the area, this procedure involves a sequential deployment that, at each step, makes use of an optimization algorithm, considering the outcome of previous stages to establish the locations of additional dosimeters in a new stage. In a next phase, we will study the potential correlation of the obtained measurement data with different parameters, such as the period of time. The acquired knowledge can afterwards be exploited to fine-tune simulation platforms, which could then be used to assess the possibilities of some management techniques that are being studied within the LEXNET project framework.

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REFERENCES

1. M. Tesanovic et al., "The LEXNET project. Wireless networks and EMF: Paving the way for low-EMF networks," *Vehicular Technology Magazine, IEEE*, vol. 6, no. 2, June 2014.
2. L. Diez, S.M. Anwar, L. Rodriguez de Lope, M. Le Hennaff, Y. Toutain, R. Agüero, "Design and integration of a low-complexity dosimeter into the smart city for EMF assessment", 2014 European Conference on Networks and Communications (EuCNC), pp.1-5, June 2014. DOI: 10.1109/EuCNC.2014.6882637.
3. "EU FP7 Project Smart Santander (ID 257992)." [Online]. <http://www.smartsantander.eu>
4. Y. Corre and Y. Lohanen, "Three-dimensional Urban EM Wave Propagation Model for Radio Network Planning and Optimization Over Large Areas", *IEEE Trans. on Vehicular Technology*, Oct. 2009.
5. S. Aerts, D. Deschrijver, W. Joseph, L. Verloock, F. Goeminne, L. Martens, T. Dhaene. "Exposure assessment of mobile phone base station radiation in an outdoor environment using sequential surrogate modeling". *Bioelectromagnetics* 34, 300–311.
6. S. Aerts, D. Deschrijver, L. Verloock, T. Dhaene, L. Martens, W. Joseph. "Assessment of outdoor radiofrequency electromagnetic field exposure through hotspot localization using kriging-based sequential sampling". *Environ. Res.* 126, 184–191.

